Evolution of multiple disease screening in Keelung: a model for community involvement in health interventions?

Po-En Wang, Ting-Ting Wang, Yueh-Hsia Chiu, Amy Ming-Fang Yen and Tony Hsiu-Hsi Chen

INTRODUCTION

As many developing countries in Asia are faced with increasing incidence of cancers and other chronic diseases that are amenable to early detection by screening, population-based mass screening for early detection of these diseases has become an important issue. The implementation of organized population-based screening in western countries is largely guided by the concept of evidence-based medicine, dependent on the results of randomized trials, as in screening for breast or colorectal cancers. Programmes tend to be aimed at individual cancers. For example, screening for breast cancer and screening for cervical neoplasia are usually carried out independent of each other, in terms of timing, setting and facilities. The provision of multiple disease screening services for more than one disease is not generally practised.

The Keelung project is an innovative programme of multidisease screening, including several cancers and several non-malignant chronic diseases, in the city of Keelung, Taiwan. It was developed in line with the ethos of primary health care in the World Health Organization (WHO) Alma-Ata declaration. The latter statement emphasizes equity (delivery of service to all parts of the community), participation (having the community take responsibility by involvement of community members and volunteers in health-care delivery) and collaboration (involvement of non-medical agencies in health-care promotion or delivery). In this paper, we assess these features of the Keelung programme.

The first results of the Keelung programme have already been published. These published results do not include an economic analysis. From the cost-effectiveness viewpoint, several potential benefits may be derived from multiple screening services. There may be a beneficial effect on attendance rates. The multiple screening programme in Keelung, Taiwan, was accompanied by an increased attendance for cervical screening. Second, there may be economies of scale in administration and service provision, and additionally from the fact that some diseases are strongly associated with each other, for example, colorectal...
cancer and hypertension. Third, because some chronic
diseases are associated with certain cancers, multiple
screening gives an opportunity to offer primary health
education for reducing morbidities of chronic diseases,
which in turn leads to morbidity or mortality reductions
for specific cancers. The major disadvantage of multiple
screening is the potentially high initial cost of early
investment in a series of multiple activities with the benefit
only being observed some years later. We therefore also
report on a simulation study of costs and effects in multi-
disease and single disease screening in this paper, using a
subgroup of the diseases screened for in the Keelung
programme, as a first step towards a full economic analysis
of the Keelung programme.

METHODS
The Keelung programme was originally designed to screen
for oral (visual examination) and cervical (Pap smear)
neoplasia, breast cancer (risk assessment followed by
mammography if appropriate), colorectal cancer faecal
occult blood test [FOBT], liver cancer (risk assessment
followed by ultrasound if appropriate), Type 2 diabetes
(fasting glucose), hypertension (blood pressure test) and
hyperlipidaemia (total cholesterol, high-density lipoprotein
[HDL] and low-density lipoprotein [LDL] testing). Recently,
osteoporosis (heel ultrasound densitometry) was added to
the screening remit. For the cancers and premalignancies
screened for, there is an evidence base for efficacy.3–7 For the
non-malignant chronic diseases, there is relatively little
direct evidence of efficacy in preventing mortality or
morbidity, but there is concern in Taiwan about their
prevalence. Around one-third of the population had at least
one of the non-malignant chronic diseases screened for.1
Subjects in the population list were invited to attend for
screening through invitation letter or telephone call. Each
screening activity was carried out in cooperation with local
health authorities. A series of stepwise multiple screening
activities were conducted, including registration, fasting,
blood-drawing, physiological measurement (including blood
pressure, height, weight, waist-hip ratio), questionnaire
administration, FOBT, physical examination of the breasts,
Papanicolaou (pap) smear, oral examination and health
education. The contents of the questionnaire consist of
demographic characteristics, life-style variables, family
history of cancer and chronic disease, personal history of
disease and reproductive factors. The questionnaire
responses were used to determine whether further referral
to regular mammography is indicated. The responses also
contributed to the decision process (along with a number of
serological measures) as to whether liver ultrasound was
required.

The target population consisted of residents aged over 30
years in Keelung, the most northern county of Taiwan. After
excluding subjects registered in Keelung but residing outside
Keelung, approximately 138,420 residents were listed as the
target population. It was expected to take six years to
achieve 100% invitation of the target population to multiple
disease screening. We assessed whether coverage with
screening (rather than invitation) was improving with time,
particularly in lower socioeconomic groups and old people.
We used educational level as our measure of socioeconomic
status.

The KCIS programme also provides outreaching referral
services such as the ambulatory sonographic service and
organized referral systems for colonoscopic, mammographic
and colposcopic examinations. The KCIS also aims to
facilitate the evaluation of treatment of type 2 diabetes,
particularly asymptomatic type 2 diabetes, in primary care.
We therefore investigated the changes in patterns of referral
and treatment over time.

We also considered the community aspect of participation:
to what extent has KCIS activated people in the community
to take part in the health promotion activity? In particular,
we assessed the changes over time in participation of
volunteers and non-health professionals, in particular, social
workers and students. To disseminate information about the
multiple screening programme, our project actively invited
the press and media to get involved in the screening activity.
This not only included the announcement of the screening
time schedules but also critical comment on our activities.
We also encouraged other major non-health agencies to
contribute to publicizing the screening programme and
health promotion generally. We describe these activities in
qualitative rather than quantitative terms below.

For our economic analysis, we included four cancers
(colorectal,5 breast,5 cervical6 and oral cancer),7 for which
there is a strong direct evidence base for screening. We also
included two non-malignant chronic diseases, type 2 diabetes9
and hypertension,9,10 for which there is at best
some indirect evidence of a benefit of screening. We used
Markov process models of disease progression with progres-
sion parameters estimated either from the Keelung project1
or from the literature.11–14 Parameters and costs included
transition parameters for the disease, natural history for
each disease, effects on these parameters of risk factors (e.g.
betel quid chewing and progression of oral neoplasia), risk
factor prevalence, survival, complication rates such as
perforation in colonoscopy, associations between non-
malignant chronic diseases and cancers, screening costs,
manpower costs, confirmation costs, treatment costs and
average costs for terminal care.

Screening performance parameters such as sensitivity and
specificity, and screening efficacy measures in terms of
mortality, were derived from the literature review.13–17 Full
details of the parameters simulated are available from the
authors (AMFY or THHC).

A total of 66,791 participants with the demographic
characteristics in Keelung were simulated. Each participant
in no screening (NS) followed the transition parameters
from the disease natural history without interruption by
early detection and treatment. For multiple screening (MS)
and single screening (CS), each participant was simulated
for a six-year screening programme with different inter-
screening intervals for different diseases. Details of the
regimes are given by Chen et al.1 We simulated follow-up for
20 years or until 99 years of age. Costs incurred in US dollars
and life years gained were estimated and the costs were
discounted at 5% per year.

RESULTS
Table 1 shows the screening coverage rate increasing with the
time after the introduction of the KCIS programme.
There was some health screening before programme, but it
reached only 6% of the population. By 2003, 34% of the
target population had been screened. In absolute terms, the
coverage increased most for those aged 50–79 years, and for
those of low educational status. In these groups, the
majority of the population is now covered.

The proportion of persons reimbursed for hospital health
checks who also used the outreaching services increased

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www.jmedscreen.com
during the years since the programme was introduced. Table 1 also shows how patterns of care in Keelung have changed since the programme was introduced. The number of general practitioners (rather than hospital departments) directly involved in diabetic care increased, and there was a shift in provision of sonography services to hospital rather than having the examination on the screening site. There was also a complete shift of colonoscopy referrals so that they are now referred to local services in Keelung and not to central services in Taipei. Table 1 also shows the expansion of sources of financial support for the KCIS programme over time.

Keelung also developed a training programme for volunteer social workers to provide aspects of the service including questionnaire administration, blood pressure measurement, dental hygiene training, checking for periodontal disease and health education. Tables 2 and 3 show the

### Table 1: Evolution of the equity indicators in the KCIS

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Before KCIS</th>
<th>1999</th>
<th>2003</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1. Coverage rate (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Age</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20–29</td>
<td>0.0</td>
<td>3.7</td>
<td>9.9</td>
</tr>
<tr>
<td>30–39</td>
<td>0.0</td>
<td>11.5</td>
<td>26.6</td>
</tr>
<tr>
<td>40–49</td>
<td>8.9</td>
<td>16.4</td>
<td>38.3</td>
</tr>
<tr>
<td>50–59</td>
<td>13.0</td>
<td>22.7</td>
<td>49.1</td>
</tr>
<tr>
<td>60–69</td>
<td>15.0</td>
<td>28.9</td>
<td>63.3</td>
</tr>
<tr>
<td>70–79</td>
<td>16.7</td>
<td>26.7</td>
<td>66.3</td>
</tr>
<tr>
<td>80+</td>
<td>11.8</td>
<td>17.3</td>
<td>19.8</td>
</tr>
<tr>
<td>Overall</td>
<td>6.0</td>
<td>14.7</td>
<td>34.4</td>
</tr>
<tr>
<td>(B) Educational levels</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Illiterate</td>
<td>17.8</td>
<td>35.6</td>
<td>67.2</td>
</tr>
<tr>
<td>Literate</td>
<td>14.8</td>
<td>48.1</td>
<td>88.9</td>
</tr>
<tr>
<td>Elementary School</td>
<td>12.5</td>
<td>19.5</td>
<td>48.0</td>
</tr>
<tr>
<td>Junior high School</td>
<td>4.6</td>
<td>11.9</td>
<td>30.8</td>
</tr>
<tr>
<td>High School</td>
<td>2.9</td>
<td>11.3</td>
<td>28.7</td>
</tr>
<tr>
<td>College</td>
<td>2.1</td>
<td>10.9</td>
<td>25.4</td>
</tr>
<tr>
<td>Post Graduate</td>
<td>1.6</td>
<td>14.7</td>
<td>35.2</td>
</tr>
<tr>
<td><strong>2. Proportion using outreach (%)</strong></td>
<td>5.9</td>
<td>15.5</td>
<td>20.8</td>
</tr>
<tr>
<td><strong>3. Referral and care patterns</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(A) Diabetic Care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of GPs providing diabetic care</td>
<td>0</td>
<td>26</td>
<td>47</td>
</tr>
<tr>
<td>(B) Sonography</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Patients referred to local hospital services</td>
<td>–</td>
<td>2.1%</td>
<td>38.2%</td>
</tr>
<tr>
<td>(C) Referral to colonoscopy</td>
<td>–</td>
<td>7.8%</td>
<td>100.0%</td>
</tr>
<tr>
<td><strong>4. Financial Support</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NHI</td>
<td>NHI+subsidy from local government</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NHI+subsidy from local government+</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>community-based education funding from</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>central government</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>5. Clinics or hospitals involved</strong></td>
<td>0</td>
<td>0</td>
<td>7</td>
</tr>
</tbody>
</table>

*National health insurance
GP, general practitioner.

### Table 2: Manpower involved in the fieldwork of screening of 1999 and 2003

<table>
<thead>
<tr>
<th>District</th>
<th>Social worker</th>
<th>Professional staff</th>
<th>Total manpower</th>
<th>Professional/social ratio</th>
<th>Total screened</th>
<th>Average served attendants per manpower</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>A</td>
<td>B</td>
<td>A+B</td>
<td>B/A</td>
<td>C</td>
<td>C/(A+B)</td>
</tr>
<tr>
<td>1999 Chung-chen</td>
<td>27</td>
<td>152</td>
<td>179</td>
<td>5.6</td>
<td>525</td>
<td>2.9</td>
</tr>
<tr>
<td>Chi-du</td>
<td>56</td>
<td>174</td>
<td>230</td>
<td>3.1</td>
<td>426</td>
<td>1.9</td>
</tr>
<tr>
<td>Nuannuan</td>
<td>34</td>
<td>137</td>
<td>171</td>
<td>4.0</td>
<td>412</td>
<td>2.4</td>
</tr>
<tr>
<td>Jen-ai</td>
<td>141</td>
<td>307</td>
<td>448</td>
<td>2.2</td>
<td>769</td>
<td>1.7</td>
</tr>
<tr>
<td>Chushan</td>
<td>47</td>
<td>182</td>
<td>229</td>
<td>3.9</td>
<td>867</td>
<td>3.8</td>
</tr>
<tr>
<td>Anula</td>
<td>78</td>
<td>162</td>
<td>240</td>
<td>2.1</td>
<td>563</td>
<td>2.3</td>
</tr>
<tr>
<td>Hsin-I</td>
<td>88</td>
<td>270</td>
<td>358</td>
<td>3.1</td>
<td>547</td>
<td>1.5</td>
</tr>
<tr>
<td>Total</td>
<td>471</td>
<td>1384</td>
<td>1855</td>
<td>2.9</td>
<td>4109</td>
<td>2.2</td>
</tr>
<tr>
<td>2003 Chung-chen</td>
<td>188</td>
<td>490</td>
<td>678</td>
<td>2.6</td>
<td>3347</td>
<td>4.9</td>
</tr>
<tr>
<td>Chi-du</td>
<td>249</td>
<td>462</td>
<td>711</td>
<td>1.9</td>
<td>3250</td>
<td>4.6</td>
</tr>
<tr>
<td>Nuannuan</td>
<td>212</td>
<td>644</td>
<td>856</td>
<td>3.0</td>
<td>3654</td>
<td>4.3</td>
</tr>
<tr>
<td>Jen-ai</td>
<td>237</td>
<td>476</td>
<td>713</td>
<td>2.0</td>
<td>2906</td>
<td>4.1</td>
</tr>
<tr>
<td>Chushan</td>
<td>396</td>
<td>539</td>
<td>935</td>
<td>1.4</td>
<td>4703</td>
<td>5.0</td>
</tr>
<tr>
<td>Anula</td>
<td>276</td>
<td>556</td>
<td>832</td>
<td>2.0</td>
<td>3489</td>
<td>4.2</td>
</tr>
<tr>
<td>Hsin-I</td>
<td>191</td>
<td>530</td>
<td>721</td>
<td>2.8</td>
<td>2468</td>
<td>3.4</td>
</tr>
<tr>
<td>Total</td>
<td>1749</td>
<td>3697</td>
<td>5446</td>
<td>2.1</td>
<td>23817</td>
<td>4.4</td>
</tr>
</tbody>
</table>
growth of community social workers and other volunteers. This suggested that the programme offers an opportunity to enable the community to be involved in health care. This had in turn enabled the social workers to develop health promotion models such as a lipid-reducing project, anti-obesity programmes, anti-smoking programmes and promotion of healthy diet and exercise.

The programme also invited students in the Technological College of Jing-Gou, the only nursing school in Keelung to participate in the outreaching screening service. Student volunteers comprised 18% of the volunteer workers in 2003 (Table 3).

Since the programme was an outreaching service, it offered an opportunity to interact with community leaders and non-health agencies. Examples included the publicity of the programme on public buses in Keeling and on the local cable TV system. The latter not only provided the time schedule of the KCIS programme but also issued health education messages and critical comment on the activities of the programme.

Table 4 shows the results of the simulations with respect to mortality. For cancer deaths, both MS and CS with 100% attendance rate were estimated to confer a 45-50% mortality reduction from cancer. MS with 70% attendance was estimated to reduce deaths from cancer by 34% compared with NS. CS with 30% attendance independently for each of the four regimes (i.e., 76% attendance for at least one programme and 65% attending at least two) was estimated to confer a 15% reduction. The absolute numbers of cancer deaths estimated to be prevented were 240 for MS with 70% attendance rate and 105 for CS with 30% for each screening regime. The corresponding numbers needed to invite were 279 for MS and 638 for CS. In multiple screening with 70% attendance, an additional 145 deaths are estimated to be prevented from causes related to diabetes and hypertension; however, these must be regarded as tentative estimates in view of the lesser evidence base for the efficacy of the non-malignant disease screening.

Compared with no screening, we estimated that the extra costs to gain an additional life year were US$667, $608, $4227 and $4789 for MS with 100% attendance rate, MS with 70% attendance rate, CS with 100% attendance rate and CS with 30% attendance rate, respectively (Table 5). Table 5 also suggests that in cost-effectiveness terms, MS dominated over CS in general.

Table 3 Balance of volunteer sources over time – social workers and students

<table>
<thead>
<tr>
<th>District</th>
<th>1999 Social worker volunteers</th>
<th>1999 Student volunteers</th>
<th>2003 Social worker volunteers</th>
<th>2003 Student volunteers</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1999 Social worker volunteers</td>
<td>1999 Student volunteers</td>
<td>2003 Social worker volunteers</td>
<td>2003 Student volunteers</td>
</tr>
<tr>
<td>Chung-chen</td>
<td>24 (100.0%)</td>
<td>0 (0.0%)</td>
<td>27 (86.8%)</td>
<td>34 (100.0%)</td>
</tr>
<tr>
<td>Chi-pei</td>
<td>27 (93.0%)</td>
<td>3 (6.4%)</td>
<td>30 (86.2%)</td>
<td>37 (100.0%)</td>
</tr>
<tr>
<td>Nuan-nuan</td>
<td>88 (78.4%)</td>
<td>19 (21.6%)</td>
<td>107 (76.0%)</td>
<td>126 (73.6%)</td>
</tr>
</tbody>
</table>

Table 4 Simulated results in terms of mortality by different screening regimes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Cost (US$)</th>
<th>Effectiveness (life years)</th>
<th>ICE, by reference group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS</td>
<td>MS, 100%</td>
<td>MS, 70%</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>MS, 100%</td>
<td>CS, 100%</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>MS, 100%</td>
<td>CS, 30%</td>
</tr>
<tr>
<td>MS, 100%</td>
<td>151,290,562</td>
<td>849,871.29</td>
<td>5643.08</td>
</tr>
<tr>
<td>MS, 70%</td>
<td>155,139,068</td>
<td>854,143.59</td>
<td>5837.64</td>
</tr>
<tr>
<td>CS, 100%</td>
<td>163,882,998</td>
<td>852,850.39</td>
<td>5941.62</td>
</tr>
<tr>
<td>CS, 30%</td>
<td>156,177,986</td>
<td>850,891.85</td>
<td>6134.01</td>
</tr>
</tbody>
</table>

Table 5 Simulated results of incremental cost-effectiveness analyses (ICE) by different screening regimes

<table>
<thead>
<tr>
<th>Mode</th>
<th>Cost (US$)</th>
<th>Effectiveness (life years)</th>
<th>ICE, by reference group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>NS</td>
<td>MS, 100%</td>
<td>MS, 70%</td>
</tr>
<tr>
<td></td>
<td>NS</td>
<td>MS, 100%</td>
<td>CS, 100%</td>
</tr>
<tr>
<td></td>
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<td>156,177,986</td>
<td>850,891.85</td>
<td>6134.01</td>
</tr>
</tbody>
</table>

DISCUSSION

The Keelung programme has demonstrated the development of certain important secondary preventive aspects of primary health care in terms of equity (delivery, participation and collaboration.) A key feature of these is integration of administration: different administrative institutions, not necessarily health-care institutions, cooperated in a unified effort for prevention of morbidity and mortality. There is internal integration between different divisions of the health authority, including, control and prevention of disease, medical and drug administration, health promotion,
nutrition and laboratory services. The external cooperation included the integration of health check-ups for women and elderly people conducted by social welfare organizations. A major feature of the impact of the programme has been the delivery of services to elderly and deprived groups. Also, the programme provides medical and preventive services for two remote areas in Keelung, Ma-Lin and You-Rui, where there was previously a lack of any medical service.

A consequence of the programme is the community development of self-sufficiency for the implementation of secondary prevention and downstream health education and promotion activities. Within the secondary prevention programme, health promotion and education activities are also carried out to contribute to the primary prevention of cancer and chronic diseases. In addition, there is a possibility of improving both professional standards and public knowledge of the importance of high-quality tertiary prevention in rehabilitation and recovery of health. One example is the formation of a patient club for colorectal neoplasm patients. It is likely that this has contributed to a recent rise in compliance with referral to colorectoscopy from 30 to 65%.

The economic analyses suggest that multiple disease screening can be more cost-effective than individual programmes. These results are to be regarded as suggestive rather than conclusive, since some of the non-malignant disease screening activities do not have proven efficacy. This does not mean that all the screening activities are necessary or that there is no room for further improving the programme. Although this is a community-based and service-oriented screening project, it also creates a study base for research. This includes epidemiological, health policy, medical management, occupational and environmental health research. There have also been experimental intervention studies and decision analyses. The current studies integrated into the Keelung programme include a population-based randomized trial for the evaluation of efficacy of toluidine blue staining for oral screening, the comparison of the efficacy between direct culdoscope and Pap smear screening, and prospective studies on epilepsy and Parkinson’s disease. A particular point of interest for the future is whether screening for some of the non-malignant conditions can be replaced by a population intervention. For example, blood pressure is generally high in Taiwan, and it is likely that almost all the population members would benefit from a reduction.18

There may be a role for legislation and regulation to facilitate the screening activities and their research sequelae. Legislation enables health personnel to conduct screening activities in the community without any barrier. The formation of a serum bank in conjunction with the screening would facilitate the development of biotechnology, but this probably requires a strong legislative framework to deal with ethical aspects and maintain the confidence of the public. Finally, social equity for high-risk groups with respect to cancer and chronic diseases may be facilitated through legislation to provide statutory services.

The programme activity may be criticized as duplicating the current policy of health check-ups for adults who have been reimbursed by national health insurance. However, the programme has successfully integrated the current strategy of health check-ups for adults into the model and demonstrated economic implementation in the community, making full use of the community volunteers and infrastructure already present.

Conclusions
The above-mentioned data suggest that the Keelung model can achieve major goals of primary health care at an acceptable cost, and exemplifies the principles of equity, participation and collaboration.

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